Cognitive Informatics – understanding clinical work to design better systems

Prof Johanna Westbrook
Director, Centre for Health Systems & Safety Research
Australian Institute of Health Innovation

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Cognitive Informatics (CI)

Understanding work processes within the context of human cognition and designing solutions that can improve clinical work, patient engagement and public health, Patel et al 2015
What do we know about clinical work?
AN URGENT CALL FOR MEDICAL EQUIPMENT!!!
IF DR. KILDARE SUCCEDS, MANY LIVES MAY BE SAVED!!!
Health Care is a complex adaptive system

- Agents are autonomous often pursuing different agendas
- Behaviour is emergent
- Agents work in networks. They share some common rules for behaving and work together without a central source of direction.
- Dynamic and use experimentation. Trial things and then adapt behaviours.
A complex adaptive system in action
To design technology that is effective in supporting and innovating work improving safety and outcomes it is fundamental to understanding clinical work + Human cognitive capacity
Measuring work and communication patterns in the field – linking these to outcomes

Social Network Analysis
Observational Studies
Network Emergency Department Staff

How often do you seek advice to solve a work-related problem?

- Professional clusters
- Highly connected 53% of possible ties
- Size indicates Prof Experience
- Senior Doctor

N= 103 staff – 94%

Creswick et al
Clinicians report that communication is central to reduce medication errors.
Social Network Analysis on wards

Who do you seek medication advice from at least weekly

Prescribing error rate
9.0 / 100 patient days
N=428 admissions

Prescribing error rate
19.4 / 100 patient days
N=240 admissions

84% of staff agreed that if doctors and nurses talked more frequently there would be fewer medication errors

54% agree that if doctors and nurses talked more frequently there would be fewer medication errors

Significantly lower % than Ward A, P=0.027
Same hospital, same policies and procedures yet substantial differences in the way teams organise to delivery care

HIT needs to support the work of these networks, reinforce behaviours likely to support better health outcomes
Direct Observational Studies of Clinicians

Goggle Box
~1 million Australian viewers each week
Work Observation Method
By Activity Timing
Junior Doctors - Benefits and Burden of Clinical Information Systems
Junior Doctors’ Work

Direct observational studies to capture time spent in different work tasks

**Day time** 08:30-19:00
12 junior doctors, 151 hours

**Night time** 22:00-08:00
8 junior doctors, 96 hours

**Weekend** 08:00-19:00
16 junior doctors, 160 hours
**Work is dynamic**

**Weekend Work**
- Highest % of time in clinical care
- Interrupted frequently
- Inadequate rest breaks
  - High cognitive demand

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**Percentage of Time**

* significant difference P<0.001

<table>
<thead>
<tr>
<th>Task</th>
<th>Weekend</th>
<th>Dayshift</th>
<th>Night shift</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indirect care</td>
<td>32</td>
<td>24*</td>
<td>16*</td>
</tr>
<tr>
<td>Direct care</td>
<td>23</td>
<td>13*</td>
<td>14*</td>
</tr>
<tr>
<td>Social/breaks</td>
<td>9</td>
<td>16*</td>
<td>28*</td>
</tr>
<tr>
<td>Supervision/ education</td>
<td>1</td>
<td>7*</td>
<td>2*</td>
</tr>
<tr>
<td>Multi-tasking</td>
<td>21</td>
<td>19</td>
<td>6*</td>
</tr>
<tr>
<td>Interruption rate (per hr)</td>
<td>6.6</td>
<td>2.2*</td>
<td>1.3*</td>
</tr>
</tbody>
</table>

L Richardson et al *Internal Medicine Journal*, 2016, 46, 819-825

Work is dynamic
Implications – CIS which support the dynamic nature of clinical work

Keeping track of multiple tasks

Provide guidance

Supporting fatigued users

Systems which can adapt to users’ needs at different times and in different situations
Emergency Department – window into complex adaptive system
US Emergency Department in 1960s
Aim: Understand the dynamic nature of work

- Dayshifts 08:00-18:00
- 36 Doctors – shadowed for 120 hours, 58 sessions
- Collect detailed information on all tasks and interactions
Dynamic nature of work – Senior Resident Medical Officer

Task Type
- Communication
- Direct Care
- Indirect Care
- Documentation

In Transit
- Prescribing
- Other

Prompts

Dynamic nature of work – Senior Resident Medical Officer

Time (Mins)

Task Type
- Communication
- Direct Care
- Indirect Care
- Documentation

Prompts

Dr Scott Walter
Implications of these work patterns for cognitive load and performance?

Internationally, well recognised that ED physicians experience a high rate of interruptions

Multi-tasking is promoted as a effective work strategy

Experimental evidence from psychology demonstrates interruptions and trying to multi-task add significant cognitive load task errors.
Driving and mobile phone use

Simulations show that just listening to a passenger reduces driver performance – e.g. lane deviations.

Drivers who use a mobile phone are 31% more likely to experience an accident involving injury or death.
Studies in health on the effects of interruptions on work

- Nurses interrupted during chemotherapy administration - more errors than those not interrupted (Prakesh et al 2014)

- Operating room simulation - anaesthetists who immediately responded to an interruption all failed to check a blood product before transfusion. (Liu et al 2009)
Aim: To understand the extent to which interruptions and multi-tasking may be associated with task errors
Methods

- Large Sydney ED, 36 Drs
- Tested Working Memory Capacity of Drs
- Sleep in the 24 hours prior to observation
- Demographics of drs and patient age; ED workload
- Recorded all tasks, interruptions and multi-tasking
- Identified all prescribing tasks during observations and later assessed these for errors.
Sleep

Following observation sessions Drs reported whether they had received average, > or < than average sleep in the previous 24 hours

Average sleep reported for 64.3% sessions
< average 19.6%
> average 16.1%

Average = 6.7 hours; < average = 5.6; > average 7.8

Recommended sleep for adults 7-9 hours
Interruptions and Multi-tasking

7.9 interruptions/hour; 9.4/hour when prescribing

Spent 4.6% of overall time multi-tasking

20.1% of prescribing time multi-tasking
Prescribing Errors

- 27 clinical errors, 181 legal/procedural errors
- Clinical error rate 11/100 orders; 0.4/patient
- Legal/procedural 76/100 orders; 2.6/patient

*deClifford et al 2007 Impact of an ED pharmacist on prescribing errors in an Australian Hospital. Pharm Pract Res. 37(4) 284-86*

Reported medication error rate 20/100 orders; 1.6/patient. Definitions of prescribing errors were not reported but appeared to focus more on clinical errors but included adverse drug reactions
<table>
<thead>
<tr>
<th>Legal /Procedural Errors</th>
<th>Medication Order</th>
<th>Description of error</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Incomplete order</strong></td>
<td>Oxycodone 5-10mg orally when required, up to a maximum dose of 20mg</td>
<td>Frequency omitted from order</td>
</tr>
<tr>
<td><strong>Incomplete order</strong></td>
<td>Morphine 2.5mg subcutaneously every four hours when required</td>
<td>Maximum daily dose omitted from order</td>
</tr>
</tbody>
</table>

| Clinical Errors                  |                                                                                |                                                               |
|----------------------------------|--------------------------------------------------------------------------------|                                                               |
| **Wrong strength**               | Thyroxine 50mg orally once daily                                               | Dose should have been 50mcg.                                  |
| **Wrong drug (drug-disease interaction)** | Aspirin 100mg orally once daily                                               | Prescribed for patient with corrosive gastritis/duodenitis and for whom there was no active disease for which aspirin is required. |
Clinical prescribing errors
Errors were significantly associated with:

- **Interruptions** during prescribing
  - RR 2.82 (1.23-6.49), p<0.01

- **Consultants** made fewer clinical errors than junior dr
  - p<0.002

- **Drs with higher WMC scores** had significantly fewer errors
  - For every 10 point improvement in their WMC test score there was a 19% decrease in error rate

- **Doctors with below average sleep** had a clinical error rate >15 times that of doctors who had average sleep
  - RR 16.44, p<0.001
What are the implications of these results for design of IT?
Future Directions

- Resilience engineering – focus on factors that help a complex system be safe.

Resilience

“The intrinsic ability of a system to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions.” Hollnagel, 2010

- CIS designs which recognise complexity & cognitive load - e.g.
  - support situational awareness
  - recovery from interruption
  - adaptive decision support (e.g. features appearing at different times, to different people)
“...solutions too often are created for an imaginary world based on how things ought to work, without considering the realities created by context and constraints of the actual work environment.”

(Wears et al, 2015 Ann Emerg Med)

+ Constraints of human capacity within different contexts
How far have we come?
Thank You

Johanna.westbrook@mq.edu.au